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CRUCIBLE FOR VAPOR DEPOSITION
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Specifications

1. Title of the Invention

CRUCIBLE FOR VAPOR DEPOSITION

2. Claim(s)

1. A crucible for vapor deposition comprising a cylindrical crucible having projecting protrusions provided on the inner wall in the vicinity of the jetting orifice in the upper part and a plurality of shielding plates having a diameter substantially equal to the inner diameter of said cylinder, in which the orifice for jetting gas is machined on the inside thereof, and notches fitting with the protrusions on the inner wall of the above-mentioned cylindrical crucible being formed on the outer periphery thereof.

2. The crucible for vapor deposition of Claim 1 characterized by the positions of the small holes for jetting gas of adjacent shielding plates above and below the aforesaid shielding plate being deviated mutually therewith.

3. The crucible for vapor deposition of Claim 1 or 2 characterized by the inner diameter of the crucible in the part in which the substance of the source is charged being smaller than the diameter of the aforesaid shielding plate.

Detailed Specifications

(Field of Industrial Application)

The present invention pertains to a molecular beam epitaxy ("MBE," hereafter) device, and it pertains to a crucible for vapor deposition (a molecular beam cell) having a structure ideal for obtaining a crystal

grown with satisfactory quality.

(Background of the Invention)

In MBE, the structure of the material quality (purity) of the molecular beam cell affects the quality of the grown crystal along with the quality of the vacuum in the growing chamber.

The conditions for growing a film without any surface defects (e.g., opal defects) by vacuum vapor deposition are not exceptional even with MBE while using a vapor deposition pot having a structure in which the raw material melted from the growth substrate surface cannot be observed directly. The Knudsen-cell (called "K-cell," hereafter), which is a vapor deposition source for MBE, is conical (trumpet-shaped) or cylindrical. The emitting end thereof is composed of a furnace comprising a PBN (pyrolytic boron nitride) crucible and Ta (tantalum) used primarily for heating this crucible. In this case, due to the structure of the K-cell used currently in MBE, the conditions for fabricating a satisfactory film, wherein the raw material melted from the substrate can be observed directly, are not satisfactory at all.

Moreover, typical examples of the Knudsen-cell thus far are found in "Improved Knudsen-Cell Vapor Source for Vacuum Depositions" Review of Scientific Instruments 35-7 pg. 913 by C.A. Escoffery.

(Purpose of the Invention)

To overcome the drawbacks of the conventional K-cell, an object of the present invention is to provide a crucible having a structure wherein the source melted from the substrate surface cannot be observed, a method for manufacturing this crucible, and a K-cell using this crucible.

(Outline of the Invention)

In MBE for compound semiconductors and so forth, the material quality of the crucible used in the K-cell which generates a molecular beam, a PBN which does not cause a reaction with the molecular beam raw metal material from a low to a high temperature, and has little gas adsorption and generation is used. This PBN crucible is fabricated by depositing BN (boron nitride) to a prescribed thickness on the surface of a mold fabricated from carbon or the like in a chemical vapor growth (or chemical vapor deposition; "CVD," hereafter), and subsequently removing this carbon mold. In this case, it is necessary to fabricate a crucible having an intricate structure depending on the composition of the crucible having a simple shape because it is manufactured in a CVD method. With the target crucible of the present invention, a minimum of two or more sources and plate on which a substrate is partitioned are required. It is crucial that it be an inexpensive structure and the source be refilled simply.

The crucible for vapor deposition of the present invention has the structure as follows. That is, it comprises a cylindrical crucible having projecting protrusions provided on the inner wall in the vicinity of the jetting orifice in the upper part and a plurality of shielding plates having a diameter substantially equal to the inner diameter of said cylinder, in which the orifice for jetting gas is machined on the inside thereof, and notches fitting with the protrusions on the inner wall of the above-mentioned cylindrical crucible being formed on the outer periphery thereof.

(Practical Examples of the Invention)

Practical Example 1

Figures 1(a) and (b) are a plan view and a side section of the shape of the crucible of the present invention. **1** in the drawing is a cylindrical crucible made of PBN; **2** is a shielding plate provided with several molecular beam jetting orifices **4**. Projections were provided on the inside of the cylinder of the cylindrical crucible made of PBN in equal intervals, starting from the any given distance from the opening end of the crucible. In this practical example shown in Fig. 1, three steps of projections were provided in the cylindrical perpendicular direction, and four projections were formed at a 90° angle to the circumference. As for the vertical positional relationship of the protrusions on this circumference, four protrusions are formed where the 2nd protrusion from the bottom is deviated by 45 degrees from the position of the 1st lowest protrusion from the position of the lowest protrusion, depending on the arrangement of the 1st lowest protrusion (i.e., the same position as the first lowest protrusion). Moreover, the number of these protrusions is not limited to four; there may be three, or at least four of them (although an effect from two protrusions was exerted, this was readily unstable). Consequently, two or more protrusions are more preferable. Needless to say, the positional relationship between the 1st lowest projection and the 2nd lowest projection is not limited to 45° either.

Figure 2 is a plan view of the shape of the shielding plate **2** adopted for the crucible of the practical example shown in Fig. 1. The diameter of this shielding plate is smaller than the inner diameter of the crucible

1 in Fig. 1 to the extent that rattling does not occur and the shielding plate can be taken in or out of the crucible **1** with ease. Notches **5** corresponding to the protrusions **3** of the crucible **1** are formed on the circumference of this shielding plate. Needless to say, the size of these notches **5** is larger than that of the protrusions **3**. The molecular beam jetting orifices **4** are provided in this shielding plate (four of these are formed symmetrically in this practical example).

In the installation of this shielding plate into the previously described cylindrical crucible with protrusions, this shield plate is lowered into the cylinder by way of the notched part, and in the part with the 1^{st} protrusion, lowering of this shielding plate lower than that can be prevented by rotating it, e.g., 45°. If the 2^{nd} lowest shielding plate or thereafter is installed in the same manner, a crucible having the structure shown in Fig. 1 can be assembled. Moreover, the 2^{nd} lowest protrusion **3** formed on the cylinder **1** is deviated by 45° from the 1^{st} lowest one in this practical example; hence, three of the shielding plates **2** shown in Fig. 2 having the same shape can be used. Moreover, as a result of using the crucible of this practical example as the crucible for the Ga source to grow a GaAs crystal, the surface defect density thereof was defined as 500 defects/cm^2.

Practical Example 2

Figure 3 shows the side sectional shape of a crucible wherein the diameter **6** of the crucible lower than the 1^{st} stage is smaller than the diameter of the shielding plate **2** in place of the 1^{st} lowest protrusion. Lowering of the shielding plate to the 1^{st} stage from the bottom of the

crucible can be prevented. In particular, if the diameter of the converged part is smaller than the distance **3** between the protrusions, the diameter of the shielding plate can be reduced, while the notched part can be increased and handling thereof is further facilitated. Bumping via the flanks of the crucible also could be prevented.

Practical Example 3

Figure 4 shows a side section of a crucible provided with projections having a gap without the possibility of the shielding plate being inserted therein above and below one shielding plate **2** to prevent the shielding plate **2** from moving vertically when the crucible is handled. In terms of the structure of such a crucible, shielding plates having a stable structure can be provided in a molecular beam crucible.

(Advantages of the Invention)

By using the crucible having the structure of the present invention in vacuum vapor deposition or in molecular beam crystal growth, a structure can be obtained wherein the growth conditions for a film with few defects and wherein the vapor deposition source melted from the substrate cannot be observed. The surface defect density of an actually grown film was 500 defects/cm^2, which was smaller by one digit than a conventional one (~5,000 defects/cm^2). Thus, advantages could be confirmed. By obtaining a crucible having this structure, crucible can be especially formed in an EVD method with PBN or the like. A satisfactory crucible shape could be realized even with a material having poor machinability in terms of structure thereof. And the structure of the shielding plates can be used as the optimum structure with a shape for jetting in the Cracker portion

of a Cracker cell. Moreover, although MBE was described in this practical example, needless to say the crucible also can be applied to the usual vapor deposition.

Brief Description of the Drawings

Figures 1(a) and (b) are a respective plan view and a side section of a crucible having a form in which shielding plates provided with protrusions on the inner wall thereof and with small holes corresponding to these protrusions, were combined; Figure 2 is a plan view of the shape of the shielding plate; Figure 3 is a side section of the shape of a crucible smaller than the diameter of the shielding plate; Figure 4 is a side section of a crucible having a shape wherein protrusions were provided above and below the shielding plate to prevent the shielding plate from moving.

1 denotes a cylindrical crucible; **2** denotes a shielding plate; **3** denotes a protrusion portion; **4** denotes small gas jetting holes provided in the shielding plate; **5** denotes notches used for accommodating the shielding plates in the crucible; and **6** denotes a part where the inner diameter of the source-accommodating portion is converged to prevent the lowest shielding plate from being dislodged.

Figure 1

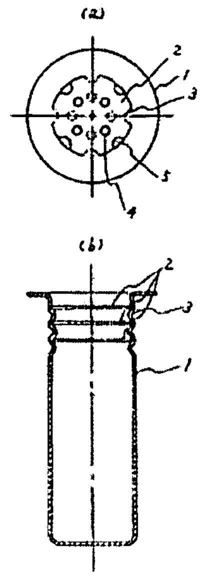

Figure 2

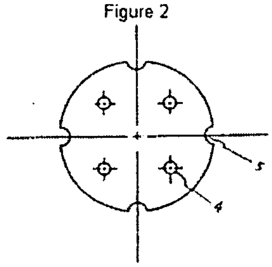

Figure 3

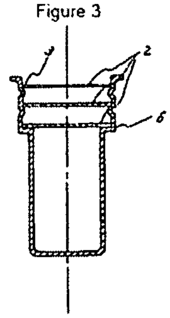

Figure 4